NEAR-INFRARED PHOTOMETRY OF JUPITER AND SATURN. R. W. Schmude, Jr., Gordon State College 419 College Dr. Barnesville, GA 30204, Schmude@gordonstate.edu).

Introduction: Astronomers have imaged extra-solar planets in near infrared wavelengths [1]. One group [2] reports a J – H value of -0.23 magnitudes for the extrasolar planet GJ 504. In spite of the extra-solar planet results, there is little information on how the brightness of Jupiter and Saturn change in the J and H passbands. Saturn has a bright ring system which undoubtedly affects the J – H value. Many extrasolar planets may have rings and by studying these we may learn more about how the rings of Saturn formed. The objective of this study is to present brightness measurements of Jupiter and Saturn using J and H filter photometry. I have also used previously published J and H filter briightness measurements of Uranus and Neptune to compute their J and H filter albedos.

Method and Materials: An SSP-4 photometer and filters transformed to the Mauna Kea J and H system were used in measuring the brightness of Jupiter and Saturn in 2014. These filters are sensitive to near-infrared radiation with wavelengths between 1.1 – 1.4 (J) and 1.5 – 1.8 μm (H), respectively. The SSP-4 photometer has a model G585 photodiode detector manufactured by Hamamatsu Corporation. It is sensitive to wavelengths of between 0.9 and 1.85 micrometers. The detector was normally operated in a cooled state at -25° C with a two stage thermoelectrically Peltier cooler. The photometer has a fixed aperture of 1.0 millimeters. This along with the telescope (focal length = 0.5 meter) produced a seven arc-minute field of view.

Measurements of Jupiter were made between April 26 and June 4, 2014. The corresponding time interval for Saturn was April 26 to September 6, 2014. All measurements were made near Barnesville, Georgia, USA at an altitude of 0.25 km. The J and H magnitude values were corrected for atmospheric extinction and color transformation.

Results: The solar phase angle of Saturn was between 0.4° and 5.8° during the study period. The J filter brightness was assumed to follow:

$$J(1,0) = J(1,\alpha) + C_J\,\alpha \qquad (1)$$

where $J(1,0)$ and $J(1,\alpha)$ are the brightness of Saturn when it is 1.0 au from the Earth and Sun at respective solar phase angles of 0° and α, C_J is the solar phase angle coefficient in magnitude/degree and α is the solar phase angle in degrees; this is the angle between the observer and the Sun measured from the target. All values of $J(1,\alpha)$ for $\alpha > 1.5°$ were plotted against α and the slope was measured using a linear least squares routine. The slope equals C_J. The H filter results were treated in the same way. For $\alpha < 1.5°$, the Saturn system had an opposition surge. At $\alpha = 0.4°$ the opposition surge was equal to 0.10 and 0.14 magnitudes in the J and H filters, respectively. Saturn's ring tilt angle, b, was close to 22° during the study period. The selected normalized magnitude values for Saturn in 2014 are $J(1,0) = -10.67 \pm 0.03$ and $H(1,0) = -10.40 \pm 0.03$. The corresponding J – H value is -0.27 magnitudes.

The normalized magnitudes of Jupiter were made at phase angles of between 7° and 10°. The selected normalized magnitudes are -9.54 and -9.07 for the J and H filter, respectively at a solar phase angle of 9°. A value of $C_H = 0.0018$ magnitude/degree was measured based on a limited range of solar phase angle values. Therefore the $H(1,0)$ value is -9.09 ± 0.05. Assuming that $C_J = C_H$, the $J(1,0)$ value of Jupiter for 2014 is -9.56 ± 0.05. A larger uncertainty is selected for Jupiter because of the uncertainty in C_H and C_J. The J – H value for Jupiter is -0.47 magnitudes.

The J and H filter geometric albedos of Jupiter were computed using the procedure in [3]. The situation for Saturn is complicated by the bright rings. Therefore, I did not compute its geometric albedo. The J (and H) filter albedo values divided by the V filter albedo value were computed for both planets. The resulting albedo ratios are summarized in Table 1. The results in Table 1 are consistent with near infrared spectra [4].

Joyce [5] reported J and H magnitudes of Uranus and Neptune. I used their values to compute normalized values of $J(1,\alpha) = -4.82$ (Uranus) and -5.08 (Neptune) and $H(1,\alpha) = -4.98$ (Uranus) and -5.23 (Neptune). I then used these values along with those of the Sun {$J(1,0) = -27.86$ and $H(1,0) = -28.17$ listed elsewhere [6]} to compute the albedos in Table 1.

Table 1: Preliminary values of the geometric albedos and albedo ratios for the giant planets

Planet (filter)	Geometric albedo	Geometric albedo ratio J/V and H/V
Jupiter (J)	0.22 ± 0.01	0.42 ± 0.02
Jupiter (H)	0.109 ± 0.005	0.20 ± 0.01
Saturn (J)	---	0.85 ± 0.03
Saturn (H)	---	0.50 ± 0.02
Uranus (J) [a]	0.021 ± 0.001	0.042 ± 0.002
Uranus (H) [a]	0.0185 ± 0.0007	0.037 ± 0.001
Neptune (J) [a]	0.029 ± 0.005	0.064 ± 0.011
Neptune (H) [a]	0.025 ± 0.005	0.056 ± 0.011

[a] J and H values are from Joyce et al. [5]; planetary radii and V(1,0) values are from Schmude [7].

References:

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